Experimental constraints on the serpentinization rate of fore-arc peridotites: implications for the welling condition of the "Arima-type" hydrothermal fluids

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In order to palce a constraint on the water circulation in subduction zones, hydration rates of peridotites have been investigated experimentally in fore-arc mantle conditions. Experiments were conducted at 400–580°C and 1.3 and 1.8 GPa, where antigorite was expected to form as a stable serpentine phase. Crushed powders of olivine ±orthopyroxene and orthopyroxene + clinopyroxene were reacted with 15 wt% distilled water for 4–19 days. The synthesized serpentine was lizardite in all experimental conditions except that of 1.8 GPa and 580°C in the olivine + orthopyroxene system, in which antigorite was formed. In the olivine + orthopyroxene system, the reactions were interface-controlled except for the reaction at 400°C, which was diffusion-controlled. Corresponding reaction rates were 7.0×10^{-12}–1.5×10^{-11} $m \cdot s^{-1}$ at 500–580°C and 7.5×10^{-16} $m^2 \cdot s^{-1}$ at 400°C for the interface- and diffusion-controlled reactions, respectively. Based on a simple reaction-transport model with these hydration rates, we infer that leakage of the slab-derived fluid from an water-unsaturated fore-arc mantle is allowed only when focused flow occurs with a spacing larger than 77–229 km in hot subduction zones like Nankai and Cascadia, whereas the necessary spacing is just 2.3–4.6 m in intermediate-temperature subduction zones like Kyushu and Costa Rica. These calculations suggest that fluid leakage in hot subduction zones may occur after the fore-arc mantle is totally hydrated, while in intermediate-temperature subduction zones, leakage through a water-unsaturated fore-arc mantle may be facilitated.

Keywords: hydration reaction, slab-fluid, serpentine, fore-arc mantle

